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Good afternoon, Chairwoman Warren, Ranking Member Scott, and members of the Subcommittee. My name is Dr. Ross Zafonte, and I am the honored to provide testimony today on traumatic brain injury and blast exposure care for members of the armed services.

My career has centered around improving the lives of people with traumatic brain injury, spinal cord injury, and other catastrophic illnesses. I currently serve as the President of Spaulding Rehabilitation, Chair of the Department of Physical Medicine and Rehabilitation (PM&R) at Harvard Medical School, and Chief of the Department of PM&R at Massachusetts General Hospital and Brigham and Women's Hospital. For the past 15 years, I have also served as Chief of Traumatic Brain Injury at Massachusetts General Hospital's Home Base program, where I developed and oversee a comprehensive brain injury and polytrauma program uniquely designed for service members and veterans, including a groundbreaking model launched five years ago that focuses on members of the Special Operations community. This program treats Special Operators who often experience the highest level of blast and extreme environmental exposures.

Throughout my career, I have published more than 400 peer-reviewed journals, articles, abstracts, and book chapters on traumatic brain injury, spasticity, and other neurological disorders. My textbook, *Brain Injury Medicine*, is regarded highly in the field of brain injury care. My current work involves several large clinical trials and has been funded by the National Institutes of Health (NIH), the U.S. Department of Defense (DOD), and the National Institute on Disability and Rehabilitation Research (NIDRR). I am also the Principal Investigator for the Football Players Health Study at Harvard University, a comprehensive research program examining the multifactorial causes that impact the health and well-being of former NFL players.[1]

[1] https://footballplayershealth.harvard.edu/team/ross-zafonte/

Blast Overpressure

Known as BOP, blast overpressure is the sudden onset of a pressure wave from explosions occurring with the use of shoulder-carried artillery and heavy armor in both training and deployment, in breaching buildings, and from improvised explosive devices. Generally, the bigger the explosion, the more damaging the pressure wave. Blast waves are often reflected off surfaces resulting in a double hit of more. For example – a blast wave can reflect from a surface such as the ground and result in a reflected pressure between two and eight times the incident pressure.[2] Recent development of blast exposure measures are helpful, recent research has suggested that the severity of the exposure may have a greater impact on brain volume. Several survey tools have been developed and a single measure may be most helpful in linking exposure to long term health concerns. Some investigators have demonstrated evidence of neuroinflammation with exposure and standard cognitive testing measures may be less sensitive to changes early in the time course after exposure.[3]

Impact of BOP on the Warfighter

Traumatic brain injury (TBI) is one of the invisible wounds of war and one of the signature injuries of troops wounded in Afghanistan and Iraq.[4] TBI can have wide-ranging physical and psychological effects. Some signs or symptoms may appear immediately after the traumatic event, while others may appear days or weeks later. Researchers and care providers classify injury into three levels of severity, although these are considered controversial and no injury should truly be considered mild—mild, moderate, and severe. These categories are based on loss of consciousness, length of memory loss and confusion and responsiveness after the injury.

Mild TBI can have long term physical, sensory, and cognitive, behavioral, or mental symptoms, including headaches, difficulty with balance fatigue, loss of balance, blurred vision, ringing in the ears, memory or concentration problems, mood changes, and difficulty sleeping. We now know that many do not recover for months.

Even after surviving a moderate or severe TBI and receiving inpatient rehabilitation services, a person's life expectancy is 9 years shorter.[5] TBI increases the risk of dying from several causes. Compared to people without TBI, people with TBI are more likely to die from seizures, infections, and pneumonia.[6] People with moderate-to-severe TBI typically face a variety of chronic health problems. Among those still alive five years after injury:

- 57% are moderately or severely disabled.
- 55% do not have a job (but were employed at the same time of their injury)
- 50% return to a hospital at least once
- 33% rely on others for help with everyday activities

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[2]. Magnuson, J., Leonessa, F. & Ling, G.S.F. Neuropathology of Explosive Blast Traumatic Brain Injury. Curr Neurol Neurosci Rep 12, 570–579 (2012). https://doi.org/10.1007/s11910-012-0303-6

[3]. Stone, J. R., Avants, B. B., Tustison, N. J., Gill, J., Wilde, E. A., Neumann, K. D., Gladney, L. A., Kilgore, M. O., Bowling, F., Wilson, C. M., Detro, J. F., Belanger, H. G., Deary, K., Linsenbardt, H., & Ahlers, S. T. (2024). Neurological Effects of Repeated Blast Exposure in Special Operations Personnel. Journal of neurotrauma, 10.1089/neu.2023.0309. Advance online publication. https://doi.org/10.1089/neu.2023.0309

[4]. https://dod.defense.gov/News/Special-Reports/0315_tbi/

[5]. https://www.cdc.gov/traumaticbraininjury/pdf/moderate_to_severe_tbi_lifelong-a.pdf

[6] Ibid.

- 29% are not satisfied with life
- 9% use illicit drugs or misuse alcohol
- 12% reside in nursing homes or other institutions

Service members experience repeated blast exposures frequently due to operating heavy weaponry including artillery and mortar firing, grenades, flash bang devices, shoulder-fired weapons, and command breaching.

According to the Department of Defense, since 2000, over 413,000 US service members experienced at least one TBI, and 40% of those with in-theater TBIs later screened positive for comorbid psychological health conditions, including post-traumatic stress disorder (PTSD), depression, and anxiety.[7]

In military settings, 4psi (~27kPa) is the current safety standard based on human tympanic membrane rupture. Studies have reported, however, that this limit can be exceeded in real world scenarios where 2-13psi (14-90kPa) has been measured.[8] The truth is that members of the Special Forces often exceed suspected safe levels of serial exposure.

Recent models suggest the cumulative effect of repeated low-level blasts (rLLB) may cause neurological deficits that develop over months. For instance, personnel who are exposed to rLLB may not show obvious symptoms right away and continue with their work which leads to further exposures and increasing the risk of injury.[9] Such repeated injury may result in axonal injury and chronic neuroinflammation, cycle that may facilitate long term dysfunction.

Long-term health issues associated with BOP exposure.

While the exact long-term effects of blast are still to be characterized, repeated brain injury has been associated with neurodegenerative disease, and recent reports suggest a specific astroglia pathology. My own research with TBI has noted an elevated 10-year risk of hypertension, endocrine and hormonal dysfunction, cardiac disease, and behavioral concerns such as depression, anxiety, and even bipolar disorder. Such work on cardiovascular risk has recently been corroborated by a military study group[10]. These findings suggest that TBI of any severity is associated with a higher risk of chronic cardiovascular, endocrine, and neurological comorbidities in patients without baseline diagnoses. Medical comorbidities were observed in relatively young patients with TBI, not just older people[11]. Recent reports have also suggested links to other neurologic illness.

[7.] DeGraba, T. J., Williams, K., Koffman, R., Bell, J. L., Pettit, W., Kelly, J. P., Dittmer, T. A., Nussbaum, G., Grammer, G., Bleiberg, J., French, L. M., & Pickett, T. C. (2021). Efficacy of an Interdisciplinary Intensive Outpatient Program in Treating Combat-Related Traumatic Brain Injury and Psychological Health Conditions. Frontiers in neurology, 11, 580182. https://doi.org/10.3389/fneur.2020.580182

[8]. Ravula, A. R., Das, T., Gosain, A., Dolalas, T., Padhi, S., Chandra, N., & Pfister, B. J. (2022). An update on repeated blast traumatic brain injury. Current Opinion in Biomedical Engineering, 24, Article 100409. https://doi.org/10.1016/j.cobme.2022.100409

[9] Ibid.

[10] Stewart, I. J., Amuan, M. E., Wang, C. P., Kennedy, E., Kenney, K., Werner, J. K., Carlson, K. F., Tate, D. F., Pogoda, T. K., Dismuke-Greer, C. E., Wright, W. S., Wilde, E. A., & Pugh, M. J. (2022). Association Between Traumatic Brain Injury and Subsequent Cardiovascular Disease Among Post-9/11-Era Veterans. JAMA neurology, 79(11), 1122–[11]. https://doi.org/10.1001/jamaneurol.2022.2682

[11.] Izzy, S., Chen, P. M., Tahir, Z., Grashow, R., Radmanesh, F., Cote, D. J., Yahya, T., Dhand, A., Taylor, H., Shih, S. L., Albastaki, O., Rovito, C., Snider, S. B., Whalen, M., Nathan, D. M., Miller, K. K., Speizer, F. E., Baggish, A., Weisskopf, M. G., & Zafonte, R. (2022). Association of Traumatic Brain Injury with the Risk of Developing Chronic

In addition, we should consider in this special population the long-term sequelae of sleep dysfunction and the chronic musculoskeletal pain that can result from multiple parachuting jumps and injuries in theatre. All of which have an impact on the service members force readiness and long-term health.

Home Base Model of Care

Home Base -- located in Charlestown, Massachusetts, with satellite locations in Florida and Arizona -- operates one of the oldest and most impactful private-sector programs in the nation dedicated to delivering lifesaving clinical care and support for the treatment of invisible wounds, including post-traumatic stress, traumatic brain injury, anxiety, depression, co-occurring substance use disorder, family relationship challenges, and other issues associated with military service.[12] Since its inception, Home Base has provided care and support to more than 35,000 veterans, service members, their families, and families of the fallen from all 50 states, 5 territories, and 13 countries—all at no out-of-pocket cost to the patient, thanks to a grateful nation of supporters.

For nearly 15 years, Home Base has been an incubator for innovative clinical care models and research. Home Base is nested within the world-renowned Massachusetts General Hospital, and our National Center of Excellence leverages the extensive resources and faculty of the Massachusetts General Hospital, Harvard Medical School, Spaulding Rehabilitation Hospital, the Massachusetts Eye & Ear Hospital, and other elements of the Mass General Brigham integrated healthcare system to deliver evidence-based care. Moreover, this incredible ecosystem we operate within provides us with insight into the latest research and clinical care opportunities and daily access to world-leading researchers and clinicians who work on the forefront of mental health and brain injury care. This ensures that our efforts to treat these invisible wounds are synchronized, not siloed.

Our research provides crucial insights into the complex interplay between single and repeated TBIs, chronic diseases, and premature aging – guiding evidence-based interventions and advancing clinical care standards. We bridge the gap between research and practice, ensuring that cutting-edge findings translate into tangible benefits for those we serve.

Home Base's Comprehensive Brain Health and Treatment Program (ComBHaT Program) and 2-Week Intensive Clinical Program (ICP)

At the end of 2018, Home Base was approached by Naval Special Warfare, a subset of USSOCOM, with a complex set of challenges facing Navy SEALS. We immediately developed a comprehensive brain injury and polytrauma program that matched the up-tempo time constraints and complex medical needs of Special Operations Forces personnel (SOF personnel).

Launched in 2019, the five-day Comprehensive Brain Health and Treatment Program (ComBHaT program) is modeled after existing programs for elite athletes, including NFL players. ComBHaT provides integrated, multidisciplinary specialist evaluation, treatment initiation, and care coordination for active-duty and veteran SOF personnel with mild and moderate TBI, leveraging the depth and breadth of specialists across the Mass General Brigham integrated healthcare system.

Cardiovascular, Endocrine, Neurological, and Psychiatric Disorders. JAMA network open, 5(4), e229478. https://doi.org/10.1001/jamanetworkopen.2022.9478

[12] Home Base is in 3 communities in Florida in partnership with FGCU, David Lawrence Center, and Tampa General Hospital, with plans to expand to the Florida panhandle in partnership with Lifeview Health. Home Base also expanded to Arizona in 2024, in partnership with Arizona State University.

Patients receive evaluations from brain injury medicine, neuropsychology, clinical psychology, psychiatry, neuroendocrinology, sports medicine, and musculoskeletal and vestibular physical therapy. Other evaluations and services are provided on an as-needed basis. Accompanying diagnostic tests include neuroimaging, hormone evaluation, metabolic testing, other laboratory testing, and cardiovascular and cerebrovascular function testing. Treatments are recommended based on evaluations and can include, but are not limited to rehabilitation, physical therapy, headache treatment, sleep interventions, medication or injection-based therapies, and home exercise programs. Each participant leaves with a comprehensive and personalized treatment and rehabilitation plan to implement in their home community.

Home Base also provides personalized needs assessment, TBI education, and support services to military family members and caregivers. Participants can matriculate into other treatment programs within Home Base or best-in-class programs in other parts of the country, as clinically indicated. Many have sufficient health problems that they are deemed eligible for our 2-week Intensive Clinical Program (ICP), which cares for all era service members and veterans from all 50 states. This outpatient program provides evidence-based therapy with complimentary holistic care to address invisible wounds of war. This innovative model of care has a 95% completion rate with treatment tracks in brain injury, mental health (PTSD, anxiety, depression) and substance use disorder. Since inception, Home Base has treated nearly 1,000 SOF through the ComBHaT program and ICP.

The ComBHaT program has cared for patients from 47 states, the District of Columbia, Guam, and Puerto Rico, including 53 patients from Massachusetts, 60 from Florida, 6 from Connecticut, 22 from Hawaii, 278 from Virginia, 4 from Illinois, 1 from Alaska, 54 from North Carolina. 71.9% of ComBHaT program participants are active duty and 178 Special Forces personnel are currently waiting to be screened and scheduled.

Benefits of the ComBHaT Program

- **Agility –** The consistent flow of patients from SOF enables us to extrapolate findings and adjust programing in real time as services are needed. The ComBHaT program serves as an incubator for brain health innovation e.g., such as the rate of cancer diagnosis we have seen in our SOF patient population has led to collaboration with the Massachusetts General Hospital Cancer Center to include cancer screening as standard protocol of the evaluation process.[13]

- **Meeting the Demand** - The program was initially piloted with Naval Special Warfare but has now expanded to serve all SOF. As of February 2024, nearly 500 SOF personnel, of which 71.9% are active-duty, have completed this unique program and 178 currently waiting to be screened and scheduled.

- **Compressed and Efficient Model of Care –** The ComBHaT program is a highly efficient, compressed 5-day care model that limits the time away from service, work, and family. Patients see a minimum of 9 medical specialists, and this number is generally higher as additional interactions occur as they pertain to diagnostic studies/imaging and specific labs. In other healthcare settings, the complex

[13] Stewart, I. J., Howard, J. T., Poltavskiy, E., Dore, M., Amuan, M. E., Ocier, K., Walker, L. E., Alcover, K. C., & Pugh, M. J. (2024). Traumatic Brain Injury and Subsequent Risk of Brain Cancer in US Veterans of the Iraq and Afghanistan Wars. *JAMA network open*, *7*(2), e2354588. https://doi.org/10.1001/jamanetworkopen.2023.54588

process of scheduling and implementing this array of specialty appointments would take months if not a year to complete.

- **Depth & Breadth** - Our affiliation to Massachusetts General Hospital allows us to leverage its extensive resources and faculty, along with clinicians and experts at Harvard Medical School, Spaulding Rehabilitation Hospital, the Mass Eye & Ear Hospital, and other elements of the Mass General Brigham integrated healthcare system, to provide patients with expeditious access to world renowned specialists without bureaucratic hurdles and barriers. Using this team-based approach, the ComBHaT program develops personalized treatment and follow-up plans for patients based on evaluations and test results.

- **Public-Private Partnership with SOCOM** - Home Base has established a direct referral pathway and served active-duty SOF personnel from every major command under SOCOM. The 12th and 13th Commanders of SOCOM, General Richard D. Clark and General Bryan P. Fenton have both visited[14] Home Base to learn more about the program and to support our collaborative partnership.

- **Serves Family Members and Caregivers** - The program serves family members and caregivers with a personalized needs assessment, education, and support services.

- **Healthspan -** Home Base is committed to enhancing the healthspan[15] of service members and veterans, recognizing that their well-being extends far beyond their mere lifespan. Through programs like ComBHaT, we're making significant strides in improving outcomes for individuals affected by traumatic brain injuries (TBIs) and chronic illnesses. Our efforts yield tangible results, including reduced TBI symptoms, enhanced cognitive function, and improved mental health, particularly in areas such as depression and trauma-related symptoms. Moreover, we're fostering resilience among our beneficiaries, equipping them with the tools to thrive despite adversity.

  Central to our mission is the understanding that polytrauma injuries, especially those impacting brain health, have profound and far-reaching consequences. We're actively investigating the long-term effects of these injuries, which encompass a spectrum of physical and psychological ailments ranging from neurodegenerative diseases to behavioral health disorders and even cancer. Through my research and collaboration with specialists, we're uncovering critical insights that inform evidence-based interventions and elevate standards of clinical care.

  Our commitment to comprehensive evaluation has unearthed cases of serious illnesses such as myasthenia, Parkinson's, and tumors affecting the head and neck region among SOF personnel. By swiftly identifying and addressing these life-threatening conditions, we ensure that our beneficiaries receive world-class care from a multidisciplinary team of experts. This integrated approach not only saves lives but also underscores our dedication to delivering tangible benefits to those we serve.

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[14] Special Operations Forces Wounded Warriors receive specialized brain-health care (socom.mil)

[15] Grashow, R., Shaffer-Pancyzk, T. V., Dairi, I., Lee, H., Marengi, D., Jr, Baker, J., Weisskopf, M. G., Speizer, F. E., Whittington, A. J., Taylor, H. A., Jr, Keating, D., Tenforde, A., Guseh, J. S., Wasfy, M. M., Zafonte, R., & Baggish, A. (2022). Healthspan and chronic disease burden among young adult and middle-aged male former American-style professional football players. British Journal of Sports Medicine, 57(3), 166–171. Advance online publication. https://doi.org/10.1136/bjsports-2022-106021

The ComBHaT program serves as a cornerstone in our pursuit of extending healthspan and improving overall well-being. By elucidating the complex interplay between TBIs, chronic diseases, and premature aging, we're driving forward evidence-based interventions that bridge the gap between research and practice. Through our unwavering commitment to excellence, we're not just prolonging lives but enhancing the quality of life for service members and veterans alike.

Summary and Recommendations

We are grateful for the support Congress, especially Chairwoman Warren, has shown for this program, and for the partnership and financial support provided by SOCOM. The program has been successful. Patients have shown a reduction in TBI symptoms, improved cognitive function, improvements in psychiatric symptoms, specifically depression and trauma-related symptoms, and enhanced resiliency.

The ComBHaT program provides crucial insights into the complex interplay between single and repeated TBIs, chronic diseases, and premature aging, guiding evidence-based interventions and advancing clinical care standards. We bridge the gap between research and practice, ensuring that cutting-edge findings translate into tangible benefits for those we serve.

Based on my experience in this field and treating patients at Home Base, I recommend the Department of Defense:

1. Invest resources and develop a series of consistent physiological and non-physiologic tools to measure blast exposure.
2. Continue to support and increase funding for public-private partnerships with academic medical centers for programs like ComBHaT and the 2-week Intensive Clinical Program to enable access to world-class treatment without barriers.
3. Ensure all active-duty service members with blast overpressure exposure and TBI can easily access high-quality care to address the full spectrum of injuries, no matter where they are deployed.
4. Develop novel methods to define and understand the impacts of declining healthspan in active-duty service members and develop a tool to measure intervention over a longitudinal period of time.

I also recommend the Department of Defense partner with Home Base to:

1. Develop a long-term longitudinal healthspan study[16] to capture the impact of multisystem injury from repeated brain injury and blast exposure.
2. Invest in research that evaluates and treats the long-term sequelae of repeated brain injuries and blast exposure.

Thank you for the opportunity to testify on this very important topic.

[16] Grashow, R., Shaffer-Pancyzk, T. V., Dairi, I., Lee, H., Marengi, D., Jr, Baker, J., Weisskopf, M. G., Speizer, F. E., Whittington, A. J., Taylor, H. A., Jr, Keating, D., Tenforde, A., Guseh, J. S., Wasfy, M. M., Zafonte, R., & Baggish, A. (2022). Healthspan and chronic disease burden among young adult and middle-aged male former American-style professional football players. British Journal of Sports Medicine, 57(3), 166–171. Advance online publication. https://doi.org/10.1136/bjsports-2022-106021